A BIOLOGICAL ASSESSMENT OF SITES ON SULLIVAN AND SKYLAND CREEKS: FLATHEAD COUNTY, MONTANA
Project TMDL- C08

August 2002

A report to

The Montmontana Department of Environmental Quality
Helena, Montana

by

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May 2003

INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in August 2002 from two sites on Sullivan Creek and one site on Skyland Creek in Flathead County, Montana. These study sites lie within the Canadian Rockies ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples.

METHODS

Samples were collected in August 2002 by Montana DEQ and US Environmental Protection Agency personnel. Sample designations and site locations are indicated in Table 1a. The site selection and sampling method employed were those recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). The "traveling kick" collection procedure was employed for the samples; duration and length for only two of the samples was provided and are indicated in Table 1b. Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana, for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1a. Sample designations and locations. Sites are listed by drainage in upstream-to-downstream order. Sullivan and Skyland Creeks, August 2002.

Site	*Station ID*	*Activity ID*	*Location Description*	*Latitude/ Longitude*
SUL1	C08SULLC01	02-C200-M	Sullivan Creek above confluence with Conner Creek	47°0'58.536"/113°0'40.122"
SUL2	C08SULLC02	02-C201-M	Sullivan Creek below Quintonkian	48°0'1.668"/113°0'42.312"
SKY	C08SKYLC01	02-C202-M	Skyland Creek above confluence with Bear Creek	48°0'17.574"/113°0'23.34"

Table 1b. Sample collection procedure, duration, and length. Sullivan and Skyland Creeks, August 2002.

Site	**Sampling Date**	**Collection Procedure**	**Duration**	**Length**
SUL1	8-22-02	KICK	Not recorded	Not recorded
SUL2	8-22-02	KICK	2 MINUTES	40 FEET
SKY	8-23-02	KICK	1:21 MINUTES	20 FEET

To assess aquatic invertebrate communities in this study, a multimetric index developed in previous work for streams of western Montana ecoregions (Bollman 1998a) was used. Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998a). The multimetric index used in this report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in western Montana ecoregions is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because, both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998a). In addition, they are relevant to the kinds of impacts that are present in Sullivan and Skyland Creeks. They have been demonstrated to be more variable with anthropogenic disturbance than with natural environmental gradients (Bollman 1998a). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific

conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.

2. Plecoptera (stonefly) taxa richness. Stoneflies are particularly susceptible to impairments that affect a stream on a reach-level scale, such as loss of riparian canopy, streambank instability, channelization, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.

3. Trichoptera (caddisfly) taxa richness. Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.

4. Number of sensitive taxa. Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998a).

5. Percent filter feeders. Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Here they are considered predators, and, in this study, their abundance does not contribute to the percent filter feeders metric.

6. Percent tolerant taxa. Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges as well as in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998a).

	Score			
Metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 – 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 – 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 – 35	> 35

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman 1998b). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a

correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998a). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).

- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent predators. Aquatic invertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Aquatic invertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman 1998b).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman 1998b).

RESULTS

Habitat Assessment

Table 4 shows the habitat parameters evaluated, parameter scores and overall habitat evaluations for the study sites. Overall habitat conditions received positive evaluations; all sites studied were categorized as optimal.

At the upper site on Sullivan Creek (SUL1), assessment of the instream habitat parameters suggested that benthic substrates were somewhat less diverse than expected, although no appreciable sediment deposition or embeddedness was noted. Flow conditions were judged sub-optimal. Streambank stability and vegetation appeared sub-optimal, and the riparian zone width was mildly abbreviated.

At the lower site on Sullivan Creek (SUL2), some sediment deposition was reported, and benthic substrate diversity was somewhat depressed. Sub-optimal flow conditions were noted here. Streambank stability was judged marginal on one side of the channel and sub-optimal on the other side; some disruption of vegetative protection was appraised. Riparian zone width appeared to be somewhat foreshortened.

Benthic substrates were mildly embedded, and sediment deposition was noted in the evaluated reach of Skyland Creek (SKY). Substrates were less diverse than expected. Streambanks were judged stable, although some disruption of vegetation was reported, and some erosion potential was reported relative to higher floodplain terraces. On one side of the channel, mild abbreviation of the riparian zone was noted.

Table 4. Stream and riparian habitat assessment. All 3 sites were assessed based upon criteria developed by Montana DEQ for streams with riffle/run prevalence. Site locations are given in Table 1a. Sullivan and Skyland Creeks, August 2002.

Max. possible score	Parameter	SUL1	SUL2	SKY
10	Riffle development	10	10	9
10	Benthic substrate	8	8	8
20	Embeddedness	20	20	15
20	Channel alteration	20	20	20
20	Sediment deposition	20	15	15
20	Channel flow status	14	14	19
20	Bank stability	8 / 6	5 / 3	9 / 9
20	Bank vegetation	8 / 6	8 / 7	8 / 6
20	Vegetated zone	8 / 8	8 / 6	8 / 9
160	Total	136	124	135
	Percent of maximum	**85%**	**78%**	**84%**
	CONDITION*	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**

Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. (Plafkin et al. 1989).

Bioassessment

Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b above show criteria for use-support categories (Bukantis 1998) and impairment classifications (Plafkin et al. 1989) recommended by Montana DEQ.

When this bioassessment method is applied to these data, resulting scores suggest that all 3 evaluated sites fully supported designated uses, and were essentially unimpaired biologically. Invertebrate assemblages, metric performances, and scoring were remarkably similar among the sites studied.

Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and other expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

High mayfly taxa richness (8) and a low biotic index value (1.27) suggest that water quality at the upper site on Sullivan Creek (SUL1) was unimpaired by nutrients or other pollutants. The site supported 6 cold-stenotherm taxa; cold, clean water appears to have been the rule here. Tolerant organisms composed a larger-than-expected proportion of the sampled animals, but a single taxon comprised the tolerant class at the site. This was the frequently-collected mayfly *Baetis tricaudatus*. The designation of this animal as "tolerant" may be

Table 5. Metric values, scores, and bioassessments for 3 sites on Sullivan and Skyland Creeks, August 2002. Site locations are given in Table 1a.

	SITES		
	SUL1	SUL2	SKY
METRICS		**METRIC VALUES**	
Ephemeroptera richness	8	8	7
Plecoptera richness	4	5	4
Trichoptera richness	5	6	7
Number of sensitive taxa	7	6	4
Percent filterers	0	0	0
Percent tolerant taxa	17.68	11.74	25.14
		METRIC SCORES	
Ephemeroptera richness	3	3	3
Plecoptera richness	3	3	3
Trichoptera richness	3	3	3
Number of sensitive taxa	3	3	3
Percent filterers	3	3	3
Percent tolerant taxa	1	1	1
TOTAL SCORE (max.=18)	16	16	16
PERCENT OF MAX.	**89%**	**89%**	**89%**
Impairment classification*	**NON**	**NON**	**NON**
USE SUPPORT †	**FULL**	**FULL**	**FULL**

† Use support designations: See Table 3a.
* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

questionable; arguably, in this case ubiquity has been confused with tolerance.

Fourteen "clinger" taxa were among the sampled assemblage, and 5 caddisfly taxa were present. These findings suggest that fine sediment deposition did not substantially limit hard substrate habitats. The overall taxa richness (24) seems low, but probably within expectations for a small montane stream. No fewer than 6 predator taxa were present at the site, suggesting that instream habitats were varied and available. Reach-scale habitat features, such as riparian zone function, streambank stability, and natural channel morphology were likely intact; four stonefly taxa were collected, and the richness of this insect order may be associated with large-scale habitat integrity. Among the stoneflies present at the site were the sensitive perlodids *Kogotus* sp. and *Megarcys* sp. Long-lived taxa were notably scarce; only 2 taxa were collected, and each was represented by but a single individual. Surface flow may be seasonal at this site. All expected functional components of an intact montane assemblage were present in the sample, but shredders were not as abundant as expected. This may be due to limited riparian inputs of large organic debris or to hydrologic conditions unfavorable for the retention of this material.

Cold water of excellent quality appears to have persisted downstream; at the lower site on Sullivan Creek (SUL2); a low biotic index value (1.32) complemented high mayfly taxa richness (8). Among the 5 cold-stenotherm taxa collected here were the mayfly *Drunella doddsi*, and caddisflies in the Rhyacophila Iranda Group. *Baetis tricaudatus* was the sole "tolerant" taxon collected.

Stony benthic substrate habitats do not appear to have been compromised by fine sediment deposition, since 6 caddisfly taxa and 16 "clinger" taxa were supported at the site. Other instream habitats were probably diverse and undisturbed; this hypothesis is supported by the fact that no fewer than 10 predator taxa were present in the sample. Twenty-eight taxa occurred in the sampled assemblage, a number that seems low, but is probably consistent with a small montane stream in good condition. Five stonefly taxa were collected, suggesting that reach-scale habitat features were not deficient. The site supported only a single semivoltine taxon, which could be related to a seasonal diminishment of surface flow. The functional composition of the assemblage was composed of all expected contributors, but similar to the upper site, this reach supported fewer shredders than expected. Lack of riparian inputs or unfavorable hydrologic conditions may explain the poor representation of this group.

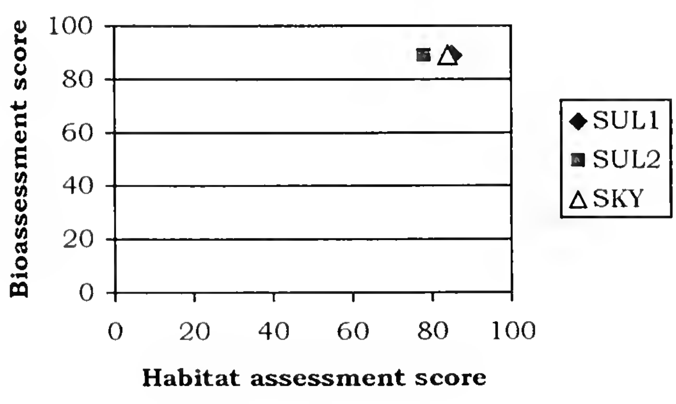
High mayfly taxa richness (7) and a low biotic index value (2.47) are evidence for unpolluted water at the site on Skyland Creek (SKY). Five cold-stenotherm taxa were present here, including the dipteran *Glutops* sp., and the stonefly *Yoraperla* sp. Cold water temperatures are indicated by these faunal elements. The (perhaps) unfairly maligned mayfly *Baetis tricaudatus* composed the "tolerant" class of organisms at the site.

Fine sediment deposition did not substantially impair substrate habitats, since 13 "clinger" taxa were collected, as well as 7 caddisfly taxa, including at least 5 species in the genus *Rhyacophila*. The total number of taxa (29) in the assemblage was within expected limits for a small montane system; ten of these taxa were predators. These findings suggest that instream habitats were diverse and available. No long-lived taxa appeared in the sampled assemblage, suggesting that surface flow may not persist year-round at this site. The site supported at least 4 species of stoneflies, which could indicate that reach-scale features such as streambanks, riparian zones, and channel morphology were basically functional. The functional composition of the assemblage included all expected groups in appropriate proportions.

CONCLUSION

- All 3 of the sites appraised in this study supported sensitive assemblages of invertebrates, suggesting excellent water quality and good instream and reach-scale habitat. Diversity appeared to be appropriate for small montane watersheds. The scarcity of long-lived taxa at these sites could imply seasonal diminishment of surface flow. Figure 1 plots bioassessment scores against habitat assessment scores. Symbols representing the 3 sites fall into the area of the graph that suggests both excellent water quality and good habitat conditions.

Figure 1. Total bioassessment scores plotted against habitat assessment scores for sites on Sullivan and Skyland Creeks, August 2002. (After Barbour and Stribling 1991).



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